# Virtual OpenFlow-based SDN Wi-Fi Access Point

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***Abstract*— With cloud services and mobile devices remodeling how we live, work and play, people expect Wi-Fi to be both fast and reliable. For ICT, facing the fast growing mobility demand needs a more agile WLAN. Software Defined Networking (SDN) offers programmability, a logically centralized control model, and a flow-based paradigm that is perfectly designed for highly scalable mobile and Wi-Fi networks. Our approach provides an agile and cost-effective communications platform for addressing these challenges, while attaining the high degree of scalability, security, and flexibility needed to support a diverse complement of services. In our work we developed a solution that allows clients to instantiate and deploy virtual OpenFlow Wi-Fi Access Points (AP) and virtual SDN controllers on the fly. By this technic, virtual instances are isolated and fully scalable for creating our SDN. Our goal is to create an architecture that is both ergonomic and flexible in order to meet the need for connection and client mobility.**

***Index Terms*—Wireless SDN, Wi-Fi, Mobility, OpenFlow AP.**

## I. Introduction

Wi-Fi networks are laborious to manage because they are subject to misconfigurations errors and important delay in troubleshooting and provisioning due to manually intensive processes. Moreover introduction of new services is always taking a long time (several weeks) because of the manual service activation, assurance, and delivery: Wi-Fi architectures are not flexible [1]. Added to that, traditional WLAN architectures based on controllers are usually closed and not programmable. In other words, most vendors use proprietary protocols for communication between the controller and the access points, and this lack of interoperability between products from different vendors can be problematic [2]. Another issue is the WLAN standard, CAPWAP (Control And Provisioning of Wireless Access Points). The CAPWAP protocol allows controllers to manage access points [3]. It was strongly modified by vendor extensions or simply not implemented in an interoperable way. There is therefore a need to correct or enhance the behavior of the WLAN architecture.

In this context, the market of wireless LAN remains extremely competitive, with suppliers such as Cisco, Aruba (recently acquired by HP), Ruckus and Meru jostling to get into business. In this environment that promotes innovation, SDN (Software-Defined Networking) appears to be one of the paradigm for optimizing deployment and management of Wi-Fi networks.

The basic principle of SDN (separate the data plane and the control plane) [4] is now something common and known by the majority of network professionals. But until recently, little was known about the use of SDN for facing limitations of today's wireless networks architecture.

In this paper we will present first the related work, then demonstrate benefits of SDN on Wi-Fi networks, and finally we will see how we developed our solution so far.

## II. Related Works

One of the biggest challenge that Wi-Fi networks have to face is client mobility. In classic architectures, once the access point detects client signal strength is too weak, it will send a message to the CAPWAP Controller that the mobile user is leaving the coverage area. At this point the CAPWAP Controller will send to the mobile client (through the same AP) recommendation about new AP to select. Once mobile user connects to another AP with a better signal, the AP will send a message through DTLS protocol (Datagram Transport Layer Security) to the CAPWAP controller which verifies client's credentials. After these steps client will connect to the new AP with a four-way handshake. At this point, roaming is achieved and client is able to access to his services.

Despite the fact that the client is connected to a new AP, the Wi-Fi network is not ready for roaming: switches still have old routing rules and reconfiguration takes time and brings additional delays for the client [3].

AeroFlux [5] is an architecture based on SDN Wi-Fi that collects wireless links characteristics with a 2-tiered (Global Controller and Near-Sighted Controller) wireless SDN control plane. This approach is useful and interesting but not depicting the whole picture of complex Wi-Fi networks involving smooth roaming in a multi-APs environment.

Chandelle [6] is a system proposing an architecture in a multi-APs context for facing to CAPWAP limitations through SDN networks for a smooth and fast roaming. The proposed solution is using traditional Wi-Fi AP on top of physical OpenFlow switches that introduce logical overhead comparing to an all-in one OpenFlow Wi-Fi AP developed from scratch.

In this context we decided to develop and implement our architecture for facing actual Wi-Fi roaming limitations using SDN Wi-Fi AP. We are virtualizing the whole system for more flexibility and scalability of our APs while maintaining same performances than legacy physical APs through hardware accelerations.



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## III. Benefits of SDN on Wi-Fi

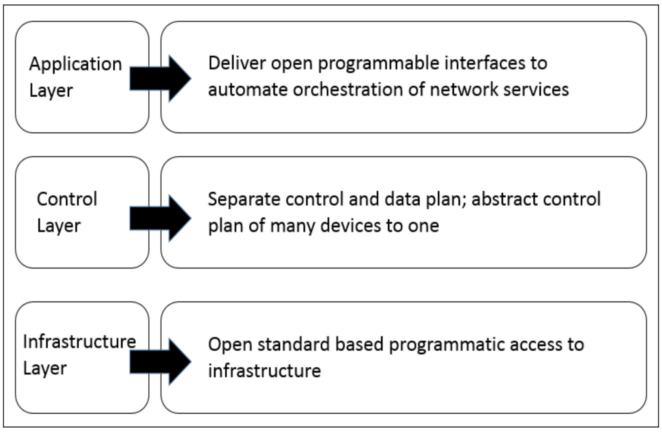


Fig. 1. SDN architecture

Figure 1 [9] shows how SDN logically abstracts the network infrastructure from the applications and services. SDN protocols like OpenFlow, ensure interoperability missing between controllers and access points in a multi-vendor environment, enabling management control and data planes. The OpenFlow agent, vSwitch [7] is now directly installed in the access point itself, which conveniently places the data plan directly in the access point. Flows table of OpenFlow provides a very accurate traffic control, allowing creation of configurations strategies both powerful and flexible.

### A. *Wi-Fi Roaming*

Wi-Fi roaming is a useful example to illustrate some of the benefits of SDN. Nowadays Wi-Fi roaming is customer driven, every time it is done clients suffer of a small latency. Roaming in a network with SDN controller could be done effectively as in cellular networks, with the benefit of a faster handover, and more prudent choice of visited AP. For example choosing the least loaded AP, over the best signal. Furthermore roaming could be done seamlessly between APs from different manufacturers, which is not feasible today without authenticating the client from scratch on the new network. With an SDN controller and appropriate APIs on the controller northbound, Wi-Fi roaming could go one step further, and possibly offload traffic without interruption from Wi-Fi to LTE [8].

### B. *Consistent user profile*

The growing of mobile devices usage in enterprises has led many companies to deploy wireless networks in parallel with their traditional wired Ethernet networks to ensure persistent connectivity for employees (Wi-Fi in meeting rooms).

More and more network equipment manufacturers are working to unify the management of wired and wireless infrastructures to enable administrators to apply the same security policies, authentication and quality of service for different access. With SDN, clients can have a unique profile and access method that grants the appropriate rights and enforces the appropriate security, while always using the same logon credentials [9].

## IV. Our Wi-Fi SDN Architecture

We developed our SDN solution on the MNetBOX produced by VirtuOR [10]. The MNetBOX is a small server based on XEN hypervisor for creating virtual instances and is equipped with an 802.11n MIMO 2x2 Wi-Fi chipset.

By definition a "virtual Wi-Fi AP is a virtual machine running on a physical AP and fitted with virtual interfaces allowing it to communicate with the physical interfaces on purpose to broadcast its SSID for allowing wireless devices to communicate with it."[11]. Virtual Wi-Fi APs that we have developed allow complete isolation between virtual instances: each one is operating independently and running on the same Wi-Fi card. Pooling resources in a Wi-Fi access point allows us to introduce more flexibility, isolation, security and extend network coverage. The idea is to optimize the use of physical resources used by a single access point. Thus, a physical machine used as the access point is shared between several virtual access points. In this virtual access point, we install and configure Open vSwitch (v2.0.0) [7]. We chose OpenDaylight Hydrogen [12] as SDN controller that we install on a virtual machine and place in our private cloud (server plugged in the LAN).

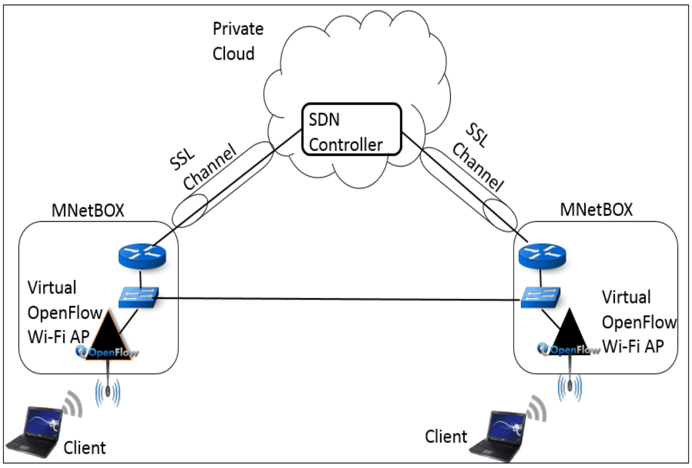


Fig. 2. Virtual Wi-Fi OpenFlow APs architecture

We could see in Figure 2, the virtualized AP with many virtual components on the top of our hypervisor for establishing intra and inter-communication with the box. The virtual SDN Wi-Fi topology is identic to traditional SDN LAN based networks with WTP (Wireless Termination Point).

With virtual Wi-Fi AP openflow-enabled wireless clients can establish a new connection over the network. The controller allows to track the location of clients, re-routing connections (by reprogramming the flow tables) during clients' mobility through the network, permitting seamless handoff from one AP to another.

When the architecture is deployed and configured, we could observe on our SDN controller all the clients connected to AP, and even the wired clients connected to the box. All wireless clients connected are visible and trackable at any moment. SDN controller could know exactly where are the clients (after a roaming) and update in real time all flows table in all AP under its control. In Figure 3 wireless clients are detected on the same AP.

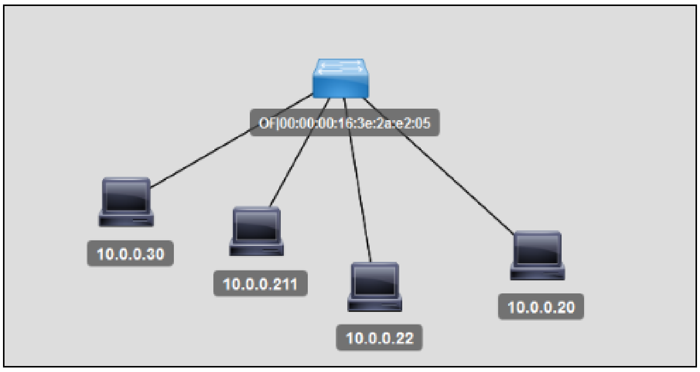


Fig. 3. Example of SDN controller display

## V. CONCLUSION

The challenges outlined in this paper compel the need for a new network architecture that overcomes the limitations of today's network architecture. Specifically, current networks are difficult to scale and manage, inflexible and too costly. With SDN networks are no longer closed or difficult to program. SDN offers a logically centralized control model, and a flow-based paradigm that is perfectly designed for highly scalable mobile and Wi-Fi networks.

In this paper, we presented our new architecture integrated in a XEN environment that mixes flexibility of SDN and scalability of virtualization allowing clients to reap full benefits of it.

This proposed solution is on its first steps, we are currently testing this architecture with many handover scenarios in order to compare them to traditional Wi-Fi access points.

## ACKNOWLEDGMENT

We would like to acknowledge VirtuOR to help us to develop our architecture and validate it on real virtualization platform. This work is a first study of SDN Wi-Fi APs, we are studying results and enhancements that could provide this new architecture, experimentations are still ongoing.

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